# Nuclear Technology Applications in the Philippines

Estelita G. Cabalfin
Philippine Nuclear Research Institute

## Backgrounder

# Radiation

- Energy traveling through space and matter
- everywhere and all around us

# Radiation

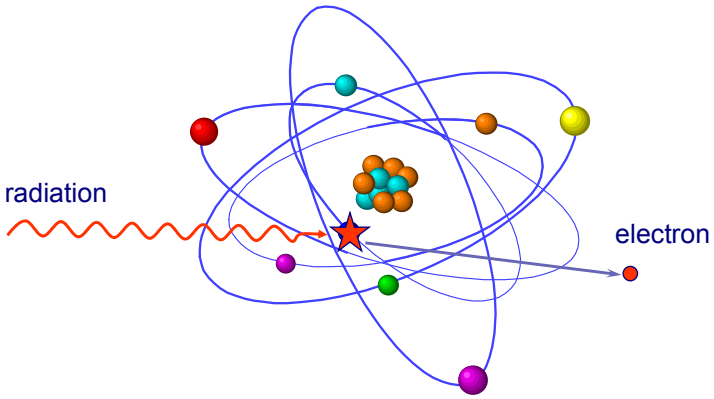
- Non-ionizing radiation

  energy are not high enough to form ions when they interact with matter

- Ionizing radiation

  energy are high enough to form ions when they interact with matter

# Ionization

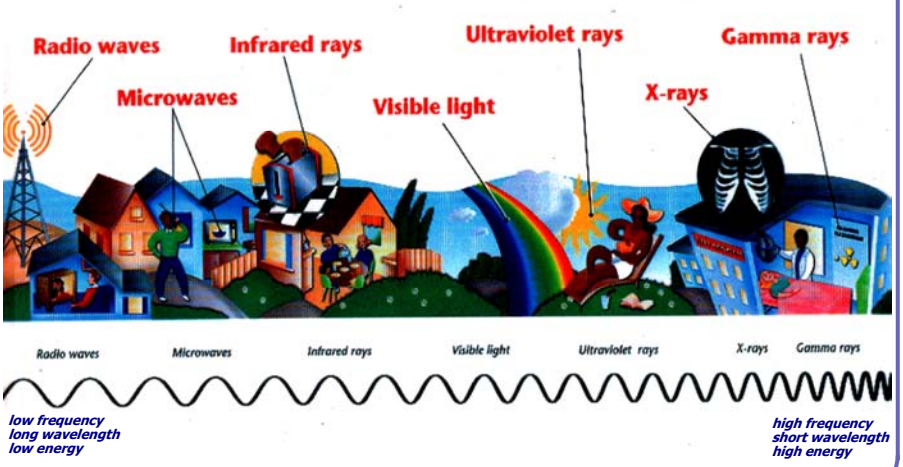



energy of radiation is enough to eject the electron from the atom; resulting in the formation of an ion pair

# Non-ionizing Radiation

- Radio waves
- Microwaves
- Infrared radiation
- Visible light
- UV rays

# Electromagnetic Radiation




# Ionizing Radiation

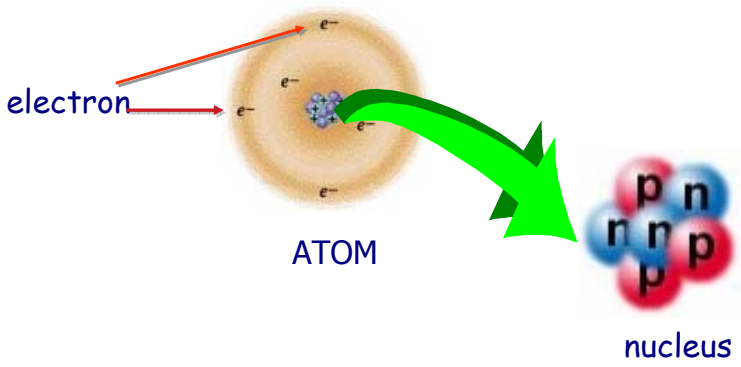
- gamma rays
- x-rays
- high energy particles
  - alpha
  - beta
  - neutron

# Ionizing Radiation

**Where does it come from?**

**How does it happen??**

- Each element consists of very small parts called "Atoms".



## WHY do certain ATOMS DECAY?

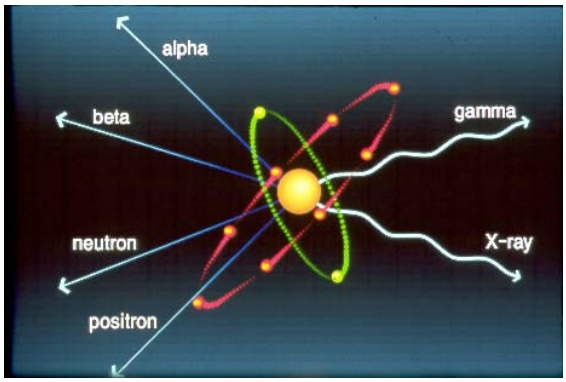
Some nuclear arrangements are "unstable"

Atoms with too much energy in their nuclei are called "radioactive".

Radioactive atoms are called "radioisotopes".

## Radioactive Isotopes

get rid of their excess energy ("DECAY") by emitting radiation.



# Nuclear Technology

Beneficial uses of ionizing radiation and radioactive materials

# Nuclear Technology Applications in:

- Agriculture
- Environment
- Medicine
- Industry

# Applications in Agriculture

- Mutation Breeding
- Sterile Insect Technique
- Fertilizer Utilization Studies

## Mutation Breeding

- Radiation can bring about hereditary changes or mutation
- Mutants with improved or desirable qualities are selected

# Mutation Breeding

**RICE**
***Oryza sativa L.* var. Bengawan**

better yield, reduced height, drought resistant, non-photoperiod sensitive

Bo Bm

# Mutation Breeding

**Soybean** high yield, early maturing, reduced height, drought tolerant

PSB-Sy 4 (Control) PSB-Sy 4 (20 Kr) BPI-Sy 4 (Control) BPI-Sy 4 (25 Kr)

# Mutation Breeding

**Foliage Ornamental**

chlorophyll mutant

*Dracaena sanderiana*

or Green Corn plant

*Dracaena sanderiana* 'Marea'

# Mutation Breeding

**Foliage Ornamental**

dwarf mutant

Orange Jasmine or "Kamuning"
(*Murraya paniculata*)

*Murraya paniculata* 'Ibarra Santos'
as a natural bonsai

## Sterile Insect Technique (SIT)

SIT involves:

- mass rearing of fruit flies
- exposure of pupae to gamma rays to make them sterile
- release of the sterile flies in the target area to mate with the wild fruit fly population.

- Continuous releases of sterile flies will eventually control or eliminate the pest.

## Fertilizer Utilization Studies

- Use of nuclear techniques to determine best combination of biofertilizer and inorganic fertilizer that will produce higher yield and better fertilizer utilization

# Applications for the Environment

- Air Pollution Characterization
- Ground Water Resource Management
- Control of Algal Bloom
- EB Treatment of Flue Gases

# Air Pollution Characterization

- Use of nuclear analytical techniques to obtain data on the relative contribution of various pollutant sources to air pollution

## Ground Water Resource Management

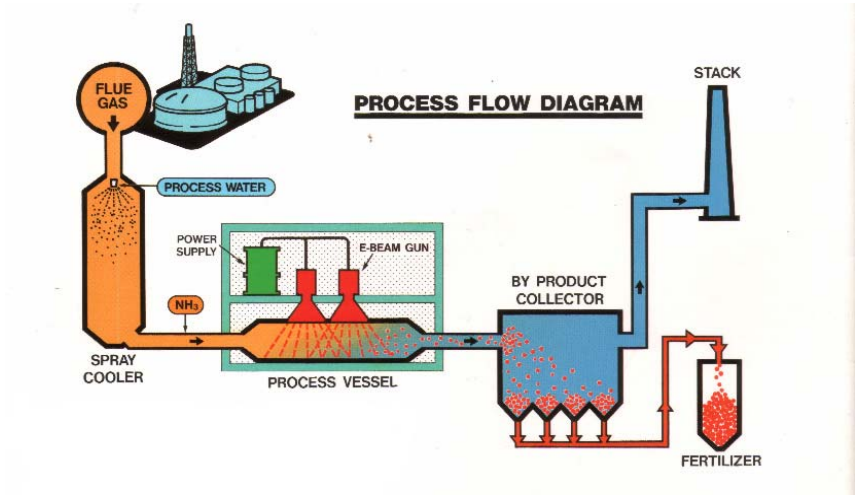
- Isotopes and chemical techniques are used to identify origin of groundwater and to assess its vulnerability to pollution

## Control of Algal Bloom (Red Tide)

- Nuclear technique can be used to rapidly detect red tide toxins
- Nuclear technique used to obtain historical profile of sediment core in red tide affected area

# EB Treatment of Flue Gases

To remove $SO_2$ and $NO_x$ an emerging technology

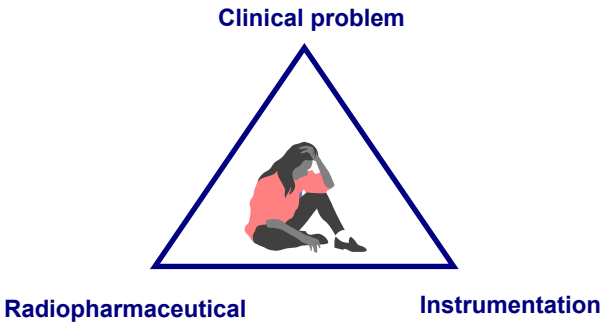



# Applications in Medicine

- Nuclear Medicine
- Radiotherapy
- Radioimmunoassay

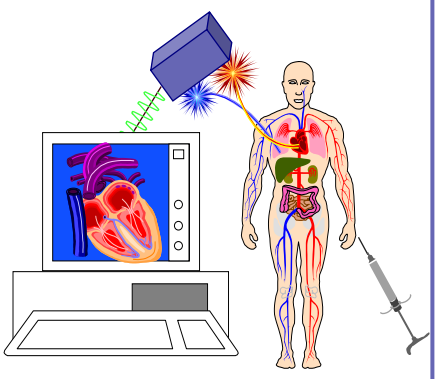
# Nuclear Medicine

- Diagnosis and therapy with unsealed radioactive sources




# Nuclear Medicine

- Imaging is done by tracing the distribution of the radiopharmaceutical within the body with a gamma camera
  - Nuclear imaging detects functional (vs. anatomical) properties of the human tissue



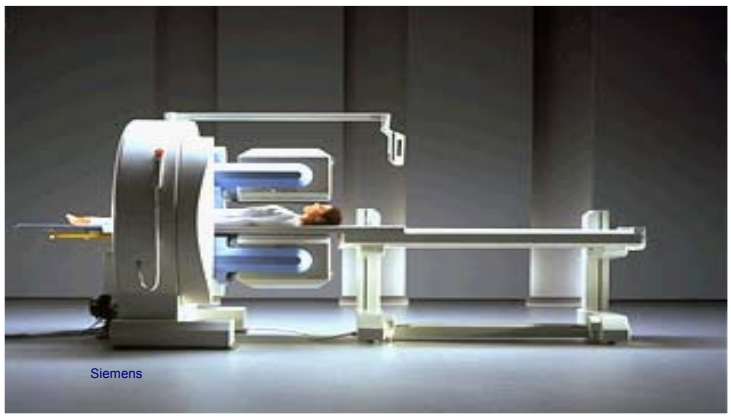
## Nuclear Medicine Procedures

- Diagnosis
  - Non-imaging (probes)
    thyroid uptake
  - Imaging
    bone, brain, lungs , thyroid, kidneys, liver/spleen, cardiovascular, stomach/ GI-tract, tumours
- Therapy
  thyroid diseases

## Gamma Counter Probe

thyroid uptake

## Gamma Camera




## Radiotherapy

One of the main treatment modalities for cancer
(often in combination with chemotherapy and surgery)

- External Beam Radiotherapy
- Brachytherapy

## Major indications for radiotherapy

- Head and neck cancers
- Gynaecological cancers (*e.g.* Cervix)
- Prostate cancer
- Other pelvic malignancies (rectum, bladder)
- Adjuvant breast treatment
- Brain cancers
- Palliation

## External Beam Radiotherapy

The patient is exposed to a radiation source, which is outside the body

- Radioactive Isotope (sealed source)
  e.g. Co-60
- Radiation emitting machine
  e.g. linear accelerator

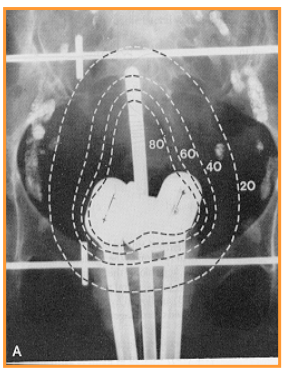
## Cobalt 60 unit

## Linear accelerator

# Brachytherapy

- The use of radioactive sources in close proximity to the target area for radiotherapy
- Brachytherapy uses encapsulated radioactive sources

# Brachytherapy




x-ray of a gynaecological implant using an applicator loaded with Cs-137 sources

## Radioimmunoassay

- An in-vitro assay, based on antigen-antibody reaction, using radioactive tracer
- Extremely sensitive method, can measure very small amount of substances in blood

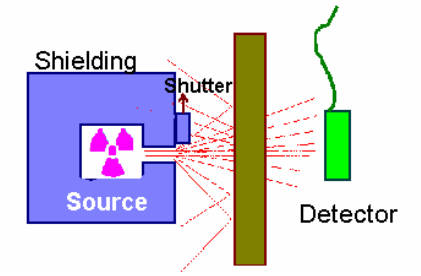
  e.g. hormones, virus, drugs, allergens

## Radioimmunoassay

# Applications in Industry

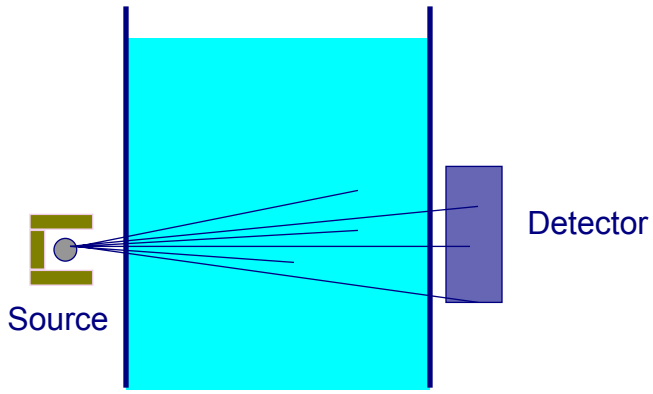
- Nuclear gauges
- Radiotracers
- Radiography
- Radiation Processing

# Nuclear Gauge



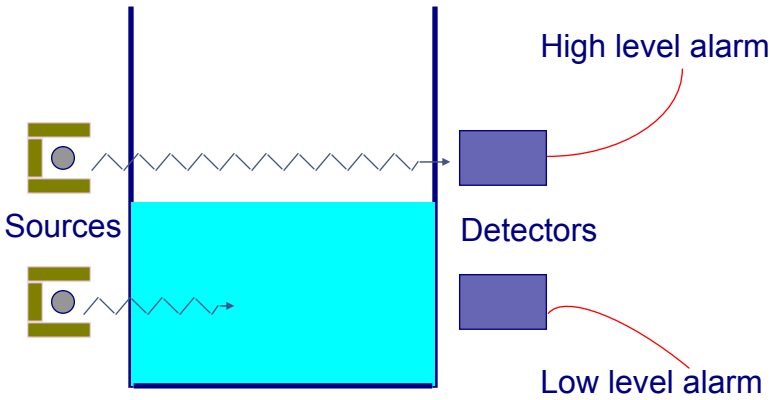

- Consists basically of a shielded radiation source and a radiation detector
- The radiation interacts with the examined material before reaching the detector, supplying real-time data.

## Density Gauge

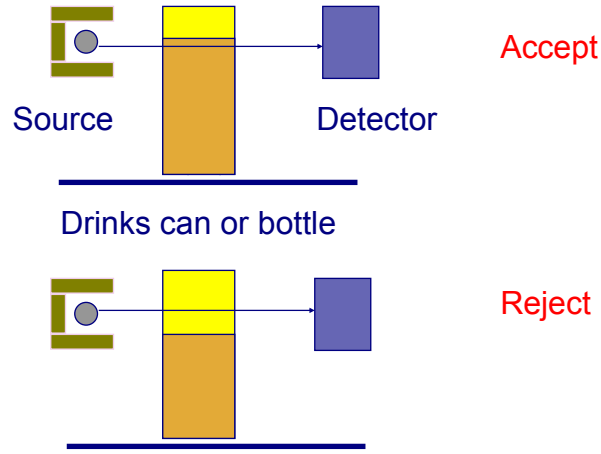



For a known thickness of material, the density can be deduced by comparing the radiation signal at the detector with and without the material in the beam

## Point Level Gauge



# Liquid fill height gauge




# Applications of gauges in industry

Quality Control

- Density: rubber, oils, fabric, paper, etc
- Thickness: paper, glass, steel, plastic films
- Level: beverages, cooking oil

Process Control

- Density: cement, mud, liquids, chemical products
- Level: vessels, silos, chemical products, minerals
- Moisture: glass, cement, minerals

# Applications of gauges in industry

Quality control

Film Thickness

Paper Thickness

Beverage Level

Oil Level

# Applications of gauges in industry

Process Control

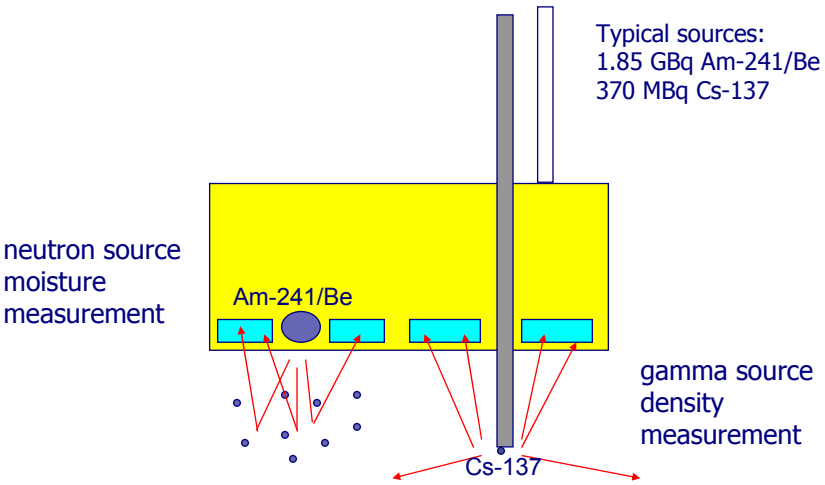
Mineral Weight

Mineral Level

Mud Flow

Liquid Flow

# Nuclear Density Gauge




# Nuclear Density Gauge

To determine compactness and moisture during road construction

## Gamma Column Scanning

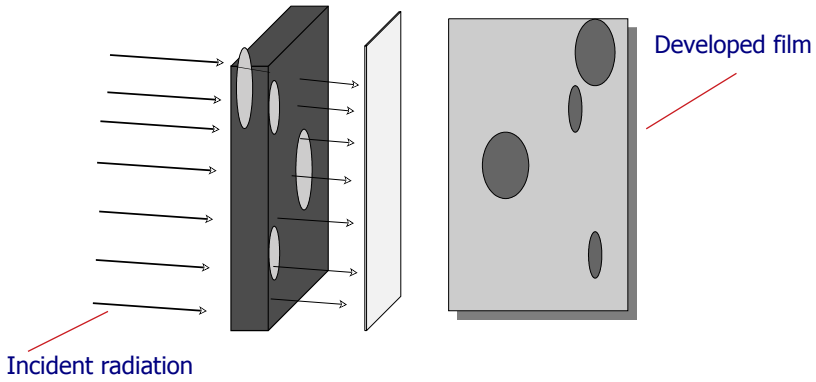
Technique using sealed radioactive source to determine or locate problems in process vessels in oil refineries, without shutting down the plant

## Radiotracers

Radiotracers are used for leak detection, flow rate measurements, leakage studies

# Radiography

- use of radiation to obtain images of materials under investigation
- key tool in non-destructive testing (NDT)




# Applications of Radiography:

Non-destructive inspection of :

- Welds
- Joints in pipework and storage tanks
- Castings (valves, engine components)
- Screening of baggage, parcels and food products

## Baggage Inspection

## Gamma Exposure Devices

**Mobile**

**Portable**

## On-site radiography


## On-site radiography

## Radiation Processing

- physical process
- which involves exposing products to ionizing radiation to get the desired effects or qualities in the product

## Radiation Processing

- Radiation Crosslinking
- Radiation Curing
- Radiation Sterilization and Microbial Decontamination
- Food Irradiation

# Radiation Crosslinking

wire and cable insulation

heat shrinkable products
(tubes, films, tapes, connectors)

# Radiation Crosslinking

foam

vulcanization of tire components

# Radiation Crosslinking

Car Parts produced by Radiation Crosslinking

- Wire and Cable
- Foam
- Shrinkable Tube
- Tire
- Polyswitch

# Radiation Crosslinking

PNRI developed an innovative and cheap dressing for burns/ wounds and bedsores from carrageenan

PVP-carrageenan hydrogel

# Radiation Curing

curing of coatings

(inks, clear or pigmented varnishes) on

- wood
- particle boards
- wrapping paper
- polymer foils
- metal


# Radiation Sterilization

use of ionizing radiation to render a product free of viable microorganisms

medical products such as disposable syringes, surgical gloves

# Microbial Decontamination

use of ionizing radiation to reduce the microbial load of a product to an acceptable level

cosmetic raw materials

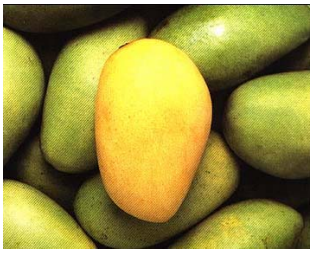
# Food Irradiation

- inhibition of sprouting

  onions, potatoes, garlic

- disinfestation

  cereals, fresh and dried fruits



# Food Irradiation

- delay of ripening

  fresh fruits

- extension of shelf life

  fresh fish, strawberries

Irradiated, 14 days storage

Non-irradiated, 7 days storage

# Food Irradiation

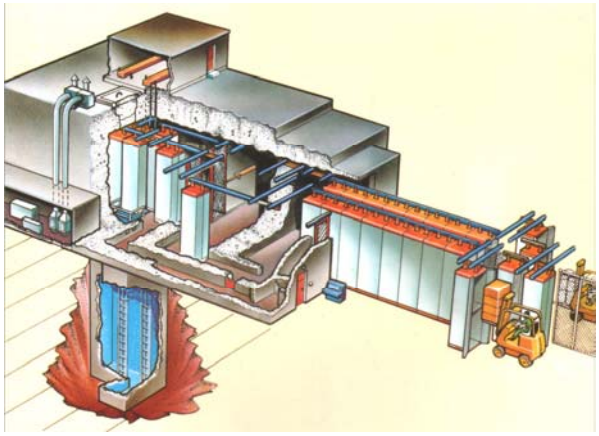
- decontamination of harmful microorganisms

  fresh and frozen seafood, meat and poultry

  spices, enzymes, dehydrated vegetables

## Radiation Processing Facilities

- Gamma irradiator



## Radiation Processing Facilities

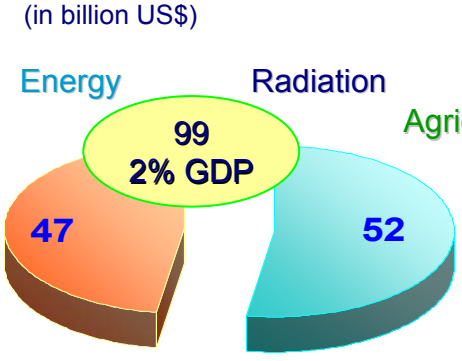
PNRI gamma irradiator

# Radiation Processing Facilities

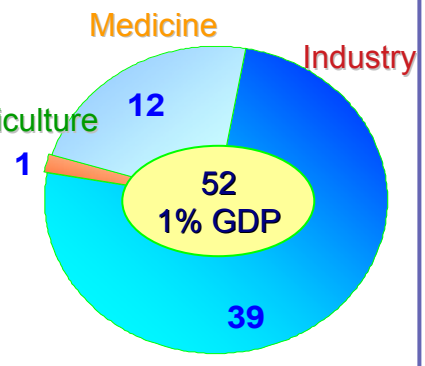
- Electron Beam irradiator

# Economic Scale of Nuclear Applications in Japan (1997)

(in billion US$)




Total economic scale of nuclear application

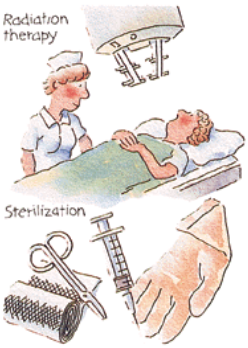



Breakdown of radiation and isotope applications

Machi 2003

Radiation can be harmful . . .

or beneficial . . .




it all depends on how we use radiation ! !

# Thank You